3 ALTERNATIVES

All of the alternatives for a new town site have the same site layout, gravel pad, and basic infrastructures, which include:

- barge and boat landing,
- water treatment and distribution system,
- sewage collection and treatment system,
- power generator system,
- airport,
- landfill,
- public buildings, and
- housing.

One possible community configuration is shown in Appendix G. This layout was developed in the "Kivalina Relocation Community Layout Plan", prepared by TNH in 2001. This layout was selected by the community as their preferred configuration. While one layout may be applicable to all sites, there will be differences, including:

- the location of the support facilities in relationship to the village gravel pad,
- the length of road to access the landing facilities,
- the thickness of the village gravel pad,
- requirements for erosion and flooding control,
- and the design issues posed.

There is not adequate data at this time to provide detailed locations of the support facilities for each site. Recommendations for the support facilities can be made on a generic level for those elements that are not site dependent. Once the site for each support facility has been selected, a detailed set of recommendations can be provided.

3.1 SUMMARY OF DESIGN CRITERIA

The following table summarizes the design criteria used throughout the Kivalina Relocation Master Plan. Design projections and assumptions were used for sizing facilities and cost estimating. Assumptions should be revaluated prior to the actual design of a new village site.

Design Criteria	Vacuum Piped System	Gravity Piped System
Planning Period	**30 years**	**30 years**
Current Population	**402**	**402**
Design Population (30-year)	**949**	**949**
Current School Population	**117**	**117**
Design School Population	**276**	**276**
Water (Entire Community)		
Average daily per capita usage (gpcd)		
2005 total average daily usage (gpcd)	47	60
2005 total maximum daily usage (gpd)	18,894	24,120
2030 design year maximum daily usage (gpd)	24,562	31,356
	44,603	56,940
Water (School)		
Average daily per capita usage (gpcd)		
2005 total average daily usage (gpd)	15	15
2005 total maximum daily usage (gpd)	1,755	1,755
2030 design year maximum daily usage (gpd)	1,755	1,755

	4,140	4,140
Wastewater (Entire Community) Average daily per capita flow (gpcd) 2005 total average daily flow (gpd) 2005 total maximum daily flow (gpd) 2030 design year maximum daily usage (gpd)	47 18,894 24,562 44,603	60 24,120 31,356 56,940
Wastewater (School) Average daily per capita flow (gpcd) 2005 total average daily flow (gpd) 2005 total maximum daily flow (gpd) 2030 design year maximum daily usage (gpd)	15 1,755 1,755 4,140	15 1,755 1,755 4,140
Solid Waste Average per capita daily production (pcpd)	Condition 7.5	Self Haul 7.5
Village Site Design Size of Proposed Village	100 acres	
Assumed thickness of Village pad in those areas with thaw unstable permafrost	9 feet thick	
Assumed thickness road bed for transportation Roads from village to other infrastructure	5 feet thick	
Notes: gpcd = gallons per capita per day gpd = gallons per day pcpd = pounds per capita per day		

3.2 NON SITE SPECIFIC ALTERNATIVES

3.2.1 Site Preparation

Site preparation is primarily dependent upon the location and condition of the chosen site. Lower elevation sites that could be susceptible to storm driven floods require raising of the site with gravel or by building on pilings; while sites that have ice-rich, warm permafrost require constructing the site without risk of thawing the ground. For the purposes of the study, and due to constructability concerns, all sites include a gravel pad for placement of future buildings and installation of utilities.

Four of the sites, Igrugaivik, Kuugruaq, Kiniktuuraq, and Simiq, have very similar existing geotechnical conditions. They each share the same geotechnical characteristics over portions of their respective areas, with ice-rich soils, marshy wetlands, and susceptibility to erosion and/or storm surge. Imnakuk Bluff also has ice-rich permafrost, but is not susceptible to storm surge. Tatchim Isua test holes show soil characteristics that are more conducive as support material. The existing Kivalina town site does not share the geotechnical characteristics of any of the other sites.

For coastal sites (Kivalina, Kuugruaq, and Kiniktuuraq), elevations are approximately 10 feet. Those sites would have to be raised to an elevation of 16.5 feet (requiring 6.5 feet of fill) to be safe from 100 year storm surge. However, to avoid degradation of permafrost, Kuugruaq and Kiniktuuraq need to be raised a to an elevation of 19 feet, requiring 9 feet of fill.

Tatchim Isua has areas without ice-rich permafrost and is located above flood levels. For this site, a gravel pad depth of 3 feet is proposed to allow leveling and/or grading of the site.

Simiq and Imnakuk Bluff are at elevations above potential flooding. However, they have soils composed of ice-rich permafrost. These two sites also require a 9 foot pad to avoid degradation of permafrost.

Kivalina has land that needs to be raised above 100 year storm surge level, which would require 6.5 feet of fill.

Techniques to keep ice-rich permafrost frozen include: gravel pads, gravel pads with insulation, thermosyphen installation, and thermopile installation. Thermosyphen and thermopile designs are usually considered for buildings and/or tank farms. In order to have buried utilities on the sites, a gravel pad is recommended so that water, sewer, and other utilities can be located below grade. Thermopile or thermosyphens may still be used for individual buildings, however this will be decided during future design phases.

For relocation sites, there are two alternatives for site preparation. One alternative is to leave the existing vegetatative mat, and build boardwalk for roads and have pile foundations for buildings. The second alternative is to build up a site pad that can be used as the basis of construction.

3.2.1.1 Boardwalk and Pile Foundations:

Under this alternative, roadways within the community would be constructed of pile supported boardwalk. The boardwalk can be designed to hold 10,000 pound loads (two ATV's side by side, each hauling a trailer). Boardwalk would be supported by helical pile foundations. Similar boardwalk construction in Chefornak and Nightmute has been constructed over warm, ice-rich, permafrost. The cost for construction was up to $1 million per mile. Buildings and utilities would be required to be founded on pile foundations systems.

The community made a decision early in the relocation study process to only consider gravel roads. Boardwalks typically are not designed for vehicle traffic and are difficult and costly to maintain. In addition, if a village site pad is constructed, gravel roads will likely be considered as part of the construction infrastructure, eliminating the need for boardwalk systems. For the purposes of this study, boardwalk systems are not being considered.

3.2.1.2 Gravel Site Pad

Most sites, with the exceptions of the Kivalina "no action" option and Tatchim Isua, require an earthen pad to serve as the stable foundation for the construction of the new village infrastructure. The chosen site should be graded and laid out to minimize storm drainage manholes, piping, and to create the best surface drainage possible. Gravel applied to the Kivalina site is for raising the elevation of the site, and is not associated with maintaining soil thermal regime.

The chosen site may have a fill section constructed over the site to allow construction of buildings, utilities, and roads. Preliminary calculations show that a gravel pad must be 9 feet thick or greater at all sites except Kivalina and Tatchim Isua. The gravel should be placed over geotechnical fabric to separate the imported gravel from the existing grade.

Access roads that do not lie within the site pad could be built with five feet of gravel, but some settlement could be expected. The roads may have to be maintained by grading and occasional placement of fill. Placing a layer of high-density foam insulation over the geotechnical fabric before placing gravel can significantly reduce the thickness of the gravel pad. However, the use of insulation is not recommended due to potential risks of permafrost melting if the insulation is damaged or destroyed. If an entire townsite was underlain by insulation, there would be a significant risk of eventually disturbing the insulation or having fuel product come into contact with the insulation. Fuel can decompose or damage the insulation. Once the insulation is damaged, the permafrost can melt or settle.

Some research has been conducted into a potential borrow source for a village site pad. The material will have to be imported by barge, or a quarry site will have to be developed near the community. Potential local sources of gravel material include local deposits at Tatchim Isua and a site located approximately 7.5 miles north west of Kivalina (see below re: Kisimigiuktuk Hill). DOWL/BBFM (1998) states that granular borrow material has been identified along the beach areas and berms of the Wulik River and Kiniktuuraq. It is estimated that more than 200,000 cubic yards of material are available from the back side of the beach berm. However, beach deposits and river deposits do not have adequate volume to develop an entire village site pad. Local beach deposits could be used for small fill projects. NANA owns about 70 percent of this deposit. The remaining 30 percent of the deposit is owned by a private party and is part of a Native Allotment.

Kisimigiuktuk Hill is located approximately 7.5 miles north east of Kivalina. The hillside is over 1100 acres in size, and has a top elevation of 460 feet (USGS quad map elevation). The site has not been investigated by a geologist. The site was visited by the Northwest Arctic Borough (NWAB) in 2005. The borough confirmed that the site has exposed weathered bedrock and there are surface deposits of gravels along the north side. In addition, the NWAB has proposed that this site be used to mine gravel for an emergency access road. Similar hillside deposits were used by Red Dog Mine to construct the port access road. Local hillsides have adequate volume to support mining for roads or village pads. For cost estimating purposes, Kisimigiuktuk Hill was chosen as a potential gravel source.

The cost of gravel to create a new village site pad has been controversial since the Phase I Kivalina Village Relocation Project report was published in December 2001. That report estimates gravel costs for a 12 ft high pad to be approximately $85 million. Later reports by others estimated the gravel cost as closer to $200 million, and up to $400 million. As part of this study, the old gravel reports were analyzed.

After further analysis of existing reports, the updated estimated costs of importing gravel to a site is $70 per cubic yard. With most sites requiring a 100 acre pad, 9 feet deep, approximately 1.5 million cubic yards of material would be required at an in-place cost of $104 million. The feasibility of mining local material was discussed with a large earthwork contractor, who estimated that mobilization, hauling, and placing fill to a site 7 miles away could take 2 to 3 years to complete.

3.2.2 Construction Phasing

The phased construction of the infrastructure and relocation of the community should take place over approximately a 10-year period. The first facility to be constructed should be the gravel borrow site. After the borrow site is constructed, a pioneer road to the new runway location can be built. Optimally, this pioneer road should be routed adjacent to the new village site and provide construction access to both sites.

The barge landing should also be constructed early in the project to facilitate the landing of barges and offloading of equipment and materials. A boat landing should also be installed to support the construction camp and contractor staging area. The remainder of the boat launch pad can be installed during subsequent construction.

The contractor(s) selected for construction of the project infrastructure must build a support camp to provide facilities and housing for construction crews. The camp, used by all contractors, should be designed and constructed to be a stand-alone facility with its own water and sewage systems. The camp should be closed down and winterized in the fall and restarted each spring prior to the arrival of the construction crew.

The temporary construction camp should be established at the boat storage pad to provide facilities for the workers building the gravel access road and the new runway. The camp can be expanded to full capacity as the phases of the construction progress.

Both the runway construction and new village pad construction should take approximately 2 to 3 years each to construct, and can be undertaken concurrently, or the runway can be constructed on a separate schedule.

If the sewage lagoon is constructed prior to the placement of the village gravel pad, it should be available for safe and sanitary disposal of wastewater as soon as community infrastructure is in place. Once the village gravel pad has been completed, construction of the community infrastructure can begin. This work should be phased to accommodate the annual budgets of the various agencies having jurisdiction over the constructed elements.

The electrical plant should be constructed followed by the bulk fuel facility. This scheduling of facilities should provide electrical power for the construction process early in the project.

Construction following the power plant should begin with the water/wastewater treatment building and the infrastructure to transport raw water to the village and discharge wastewater to the lagoon. Water and sewer infrastructure can be installed concurrently with the construction of housing and public buildings in a phased program over the last 3 years of the build-out.

During construction of the village, two villages should be functioning simultaneously. It is unlikely that both sites will have operational schools or post offices. It is more likely that once the school at Kivalina is closed, equipment and teachers will operate out of a new school at the new town site. However, since homes are projected to be built over three seasons, not all people will be able to move at once to the new site. Transportation between the new and old sites must be available for schoolchildren and for moving freight and supplies. For the relocation sites located furthest away from Kivalina (Simiq, Tatchim Isua, and Imnakuk Bluff), a hovercraft system is recommended to move school kids and equipment between villages. The hover craft would travel across the tundra between village sites, possibly using the lagoon as a primary transportation corridor. For areas on bluffs, the hovercraft would have to stop short of the village and pick up people near the river.

At the conclusion of the construction process, the temporary construction camp should be removed from the boat launch ramp, and construction of the new facilities should be finalized.

3.2.3 Water

3.2.3.1 Water Supply

A continuous year-round source of fresh water is needed to support a piped distribution system for the community. Kivalina's current water system draws raw water from a surface water source, the Wulik River, and passes it through a small treatment plant. The local residents report that the water source does not flow year-round because the river freezes up in the winter. Although the river may freeze to the bottom, it may be possible to withdraw water year round from a shallow infiltration gallery in the river bed located upstream of the ocean saline water influence. This is further supported by a stream gauge information (USGS Station ID 15747000) located on the Wulik River, approximately 25 miles northeast of Kivalina. The station shows continuous year around flows in the Wulik River. Field investigations by Travis Peterson Group also witnessed year around base flow in the Wulik River (2005 investigations)

In order to use the Wulik River as a year round water source, the transmission line would have to be heated. The line should be continuously heated by using a circulating glycol loop in the arctic pipe. Glycol heating systems work by circulating temperature controlled heated glycol in a closed loop system that is located along side the water line. Long lines are very expensive to heat and to circulate. The village site should be in close proximity to the water source in order to avoid high heating and pumping costs.

Groundwater could supply a year-round water source if found in sufficient quantity and quality. Exploratory geophysics and drilling conducted in the site vicinity suggest that thaw bulbs along the Wulik or Kivalina Rivers may be the most likely source of groundwater in the area (Golder 1997; R&M 2002). Only one test well has been drilled to date, however, which yielded saline groundwater at a location approximately 1 mile inland from Kivalina Lagoon (R&M 2002). The source of the saline groundwater may be a subsurface intrusion effect, or surface infiltration during high tides and storm surges.

A literature review of local geology and hydrology, with respect to determining the most likely location depth and yield for a public surface, or groundwater water supply source for each of the seven potential relocations sites was conducted as part of a water investigation report (Appendix H). The recommendation of the report was to utilize surface water sources for all alternatives, for a number of reasons. In summary, the drilling of wells to establish a surface water source is not feasible for Kivalina, and is not likely to yield positive results based on an analysis of regional data. A proven subsurface water source has not yet been identified in the Kivalina area.

For all sites, a surface water source would be used. The surface water intake structure would either be a shallow infiltration gallery, or a direct intake from the river. Since freezing is a concern, an infiltration gallery is the recommended alternative for all water supply systems.

3.2.3.2 Water Storage

A community-wide piped distribution system requires community water storage for water treatment requirements. If surface water is used as a water source, the tank must be sized for disinfection contact time. The size of the tank is determined by comparing the requirements for disinfection contact time and the requirements for demands.

Storage helps alleviate water shortages and provides for better fire protection by supplying a large quantity of water quickly.

A bolted steel tank insulated and heated in the winter to protect the water from freezing is necessary. Such tanks are relatively simple to build and have superior factory paint systems than welded steel tanks. A circulating heat line should also be installed in the water storage tank to keep it from freezing.

The water tank should be sized for seven days' water demand, and with extra storage for firefighting needs. The average daily water demand for a fully piped community water system for a future population of 949 is estimated at 57,000 gallons per day. Fire flow is rated at 1000 gpm for a sixty-minute period, or 60,000 gallons of storage. At a rate of 1000 gallons per minute for fire flow, and adding seven days of average daily demand, approximately 460,000 gallons for storage would be needed for a fully piped system. A contact tank (CT) would be needed for disinfection purposes. A water storage tank can act as a contact tank. The tank should to be sized for the peak daily demand (twice the average daily demand) of 94,900 gpd. A 110,000-gallon tank is a sufficient size to satisfy CT requirements. Sizing was based on a baffle factor of 0.3, and an average demand of 66 gpm on peak days. A separate calculation was run based on a demand of 132 gallons per minute. A 110,000-gallon tank is adequate for both demand rates, however the larger tank discussed above is recommended to act as both fire flow storage and a contact tank.

3.2.3.3 Water Treatment

Water treatment alternatives are dependent on the quality of the source water. Since the water quality investigations are still pending, detailed analysis of water treatment alternatives cannot be conducted at this time. In addition to the quality of the water, the level of treatment is also determined both by State and Federal drinking water regulations.

All public water systems must comply with State of Alaska Drinking water regulations: 18.AAC.80. Kivalina should be classified as a Class A public water system, with either a surface water source or ground water source. Rivers, lakes, and streams are considered surface water, while water wells are typically considered ground water. Surface water is required to have filtration and disinfection of the water, while ground water may not require any treatment if the quality is suitable. For surface water, the goals set by the EPA are to achieve 99.9 percent removal and inactivation of Giardia cysts and 99.99 percent reduction in viruses, which are commonly found in surface water. EPA also requires maintaining a disinfectant residual in the water distribution system.

A short summary of regulations that apply to the design and operation of a public water system are included on the following page:

- Lead and Copper Rule
- Long Term 1 Enhanced Surface Water Treatment Rule
- Filter Backwash Recycling Rule
- Arsenic Rule
- Radionuclides Rule
- Interim Enhanced Surface Water Treatment Rule
- Stage 1 Disinfectants and Disinfection Byproducts Rule
- Consumer Confidence Report Rule

If a river is selected as a water source, the treatment equipment will likely consist of filtration, followed by disinfection of the water. The alternatives for treatments are a packaged rapid sand filter system, or a pressure sand filter system. During the winter months, heat would have to be added to the source water to keep the water from freezing and to enhance the performance coagulation and filtration of contaminants. Both alternatives would require storage to act as a chlorine contact tank. Preliminary sizing of the CT tank requires a 110,000 gallon tank based on the design population average and peak flows of 66 gpm and 132 gpm, respectively. Calculations are based on a pH of 6.8, a free chlorine residual of 0.2 mg/l, a treated water temperature of 3 deg Celsius, and a tank baffle factor of 0.3. Based on the results of a pilot water treatment study, a water treatment system can be designed.

The water treatment plant may be housed in a building shared by the sanitary sewer vacuum plant. Having one shared facility should save on heating, construction, and maintenance costs. The treatment system is likely to be a pressure sand filter system. The technology is well known and proven, has easy to find parts and materials, and is familiar to most operators in rural Alaska. The plant should be designed to remove all contaminants found in the raw water source to levels compliant with current ADEC regulations, and should be capable of treating a minimum of 50 GPM continuously. The treated water should be stored in an insulated 460,000 gallon steel storage tank located near the water treatment plant. The water tank will require an add-heat system to keep the tank from freezing in winter months.

For any source of water, the water may have to be filtered to remove: dissolved organic material, iron, manganese, and possibly other constituents. The water would likely have to be preheated to speed up the oxidation of metals in the water. Again, without detailed water quality results, the alternative for treatment cannot be selected.

For cost estimating purposes, the treatment system selected is multimedia sand filters, with injection of polymers to coagulate particles prior to the filters. This type of filtration is common for remote communities, as it allows for a small footprint within a building, and provides very efficient treatment of the water.

3.2.3.4 Water Distribution

When selecting a particular water system for a community, the type of water distribution chosen is a major factor. The type of water distribution utilized may affect other aspects of both the water and sewer systems.

The community has selected piped water and sewer systems. However, several options for water distribution are available for the village. Preliminary alternatives include self-haul, small-scale ATV haul, truck haul, and piped distribution.

3.2.3.4.1 Self Haul

A self-haul system, where village residents haul their own water from the watering points, is currently used in Kivalina. Capital cost for this option is zero, but it does not provide a high level of service. O&M costs are primarily related to the upkeep of the watering point and to water treatment, and are the lowest of the possible alternatives. However, because individuals must haul their own water, residents tend to get water less often, consequently leading to insufficient sanitation practices.

3.2.3.4.2 Small-Scale Community ATV Haul

This distribution system uses a four-wheeler or tracked vehicle and a small trailer to transport water from the water treatment plant to residences. These systems have been found to be best suited for communities with low water consumption and good roads. Rural Alaska communities typically don’t water lawns, wash cars, or have high water use devices such as washing machines and dishwashers. Water demands can be therefore be lower per capita than that of larger cities, making this distribution method appropriate.

Water usage usually increases with availability. Currently, Kivalina is on a self-haul system, which would be considered a low availability supply system. The small-scale community ATV haul would increase availability, but not to the extent of a piped system. The major components of this system are the fill station, delivery vehicle and trailer, and storage tanks at each home. Water is pumped from the watering point to fill the ATV tank, and a small electric pump is used to pump the water from the trailer to the storage tanks in the homes. An ATV haul system serving all residents of Kivalina would be classified as a Class A public water system by the Alaska Department of Environmental Conservation (ADEC).

This option requires very little technical oversight for maintenance and operation. If the haul vehicle breaks down, there are replacement vehicles in town that could be used in an emergency. Residents could return to hauling their own water again with very little loss of service if the community sees the system as undesirable. Capital and O&M costs can be lower than other, more complex distribution systems.

Disadvantages of a small-scale haul system are the relatively small size of the ATV hauling tank, which increases the number of trips and therefore decreases the level of service. ATV haul systems typically transport and serve water tanks holding between 100 and 300 gallons. Another possible disadvantage is that indoor tanks often require the operator to enter the home to deliver the water unless an outside fill point is installed.

Small scale haul systems are usually sized to allow 15 gallons per person per day. Studies show an increase in health standards if people use 15 or more gallons per day. However, since haul systems charge per haul, people typically ration water to save haul costs. Water rationing does not promote good sanitation practices.

3.2.3.4.3 Community Truck Haul System

This option is similar to the ATV haul, but on a larger scale, utilizing a truck rather than ATV. The major components of a truck haul system include a truck fill station, the delivery vehicle and tank, and a storage tank at each home. The delivery vehicle can be a conventional 1,200-gallon water truck or it can be a pickup truck with a water tank, typically 300-500 gallons, and delivery pump mounted in the bed. The tank would be filled from a central fill point, such as the washeteria. Water would be distributed to individual storage tanks on a scheduled basis or upon request by the consumer. A truck haul system serving all residents of Kivalina would be classified as a Class A public water system by ADEC.

Advantages to this system are that it has capability of delivering more water than a self-haul or ATV haul system, thus increasing the level of service to consumers and decreasing the number of trips to the watering point, which in turn reduces both labor and fuel costs. It can also provide a limited fire control capability. Haul systems require less technical expertise than the piped water distribution systems.

Disadvantages are that haul systems are labor intensive and require an operator to run the truck and maintain it. The roads and structure access must be maintained to ensure reliability of delivery. The trucks also require a larger heated facility for storage than ATVs, and are more maintenance intensive.

3.2.3.4.4 Piped Distribution

A piped distribution system provides the highest level of service for water users and was previously chosen by the community. The consumer has water on demand whenever it is needed, without the necessity of filling tanks or hauling water. It allows the treatment of all of the Community water to be monitored, to assure safety and quality control. This control decreases the likelihood of contamination.

Piped systems are capable of providing large quantities of water to residents. Pipes would circulate heated water from the water treatment plant to the homes and back. The major components of this system are indoor plumbing, service connections, piping, and the water treatment plant upgrades.

Insulating pipes in arctic conditions is typically done one of two ways: utilidor or arctic pipe. Utilidors are often more expensive to install and maintain and are commonly used in wetlands or when multiple pipes are located close together. For this reason, arctic pipe would be suggested for a Kivalina water distribution system.

The installation of arctic pipe has several alternatives. Routing can be varied to best fit the community. The most accepted and practiced method is to place the mains in the road right-of-ways. This method greatly reduces easement requirements and also places the pipe in easy to reach locations for maintenance access.

Another option, the extended main, is to install the mains as close as possible to the houses to be served to minimize the length of the service line. This is not as common as it once was due to easement requirements and ownership complications. It also increases the length of mainlines, and places the mains at risk in the event of structure fires.

Distribution systems to serve Kivalina can be constructed with above or below ground piping. Below ground piping is commonly installed when the soil consists of unfrozen ground or thaw stable permafrost. Advantages to below ground piping are that road and sidewalk crossings do not hinder traffic and the pipes do not segregate the village. Heat loss experienced with below ground piping is approximately one third that of above ground pipes in similar climates. Aesthetics and unobstructed vehicle movement are also much improved with below ground piping. Disadvantages are that the soil surrounding the pipes must be thaw stable or kept frozen. In arctic climates, this means the soil must be granular and free of excessive moisture. Also, if a leak were to occur in buried piping, locating and repairing the leak can be difficult and costly.

Above ground piping is common in locations with ice-rich, unstable soil. Advantages to above ground pipes are that they can be less expensive to install and maintain because no excavation is required. Leaks in above ground pipes are easier to detect, locate, and repair. Disadvantages are that above ground pipes tend to segregate a village, restricting or hindering access to certain locations. Above ground pipes are subject to physical damage because they are exposed, particularly when they are installed near roads.

Through a piped distribution system, water is supplied to each home with individual water service lines that utilize pitorifices to circulate the water. In order for the pitorifice to work properly the service line cannot be over 60 feet in length and the velocity in the main line must be at or above two feet per second (2 ft/sec). In the circulation system, there are two taps and two lines, an entry line and a return line. Services are connected to the main line through a brass plug valve called a corporation stop. The corporation stops are the pitorifice type. The inlet pitorifice is pointed into the flow and the outlet pitorifice is pointed away from the flow. The service line loops into and out of the house. Small circulation pumps can be installed in the home to circulate the water if the head loss is too great for pitorifices, but would require electricity to operate and need to be maintained. The service lines are usually installed with heat tape to provide thaw recovery should circulation stop and the lines freeze. The optional meter would be attached to a tee on the top of the loop.

One advantage of a piped distribution system is that it provides the highest level of service for water users. The consumer has water on demand whenever it is needed, without the necessity of filling tanks or hauling water. This system would also allow the treatment of all of the village water to be monitored, to assure safety and quality control. This control would decrease the likelihood of contamination as compared to a haul system. A disadvantage of piped systems is that this type of system often requires major modifications to existing water treatment plant equipment, or additional central facilities, to operate. These requirements make piped systems more complicated to operate than a haul system. The technical and financial requirements to operate and maintain a circulating water system are very high in relation to what the self-haul system in place now costs users.

3.2.4 Wastewater

3.2.4.1 Wastewater Collection

Alternatives considered for wastewater collection include ATV haul (with onsite holding tanks), truck haul (with onsite holding tanks), and piped collection systems. The health concerns that a collection system addresses are the lack of or minimal contact with the waste. A trained operator or employee of the village would have appropriate clothing (gloves, boots, mask, etc.) and would be the only individual(s) in contact with the waste, reducing the disease and illnesses associated with handling human waste. Small-Scale ATV Flush/Haul

ATV wastewater haul systems are similar to those used for ATV water haul. Advantages of the ATV system are that the equipment is less complex and easier to maintain, and access needs are less demanding than for a larger scale truck haul system. Also, waste would be contained and disposed of in controlled locations, increasing sanitation. The road system would not need large-scale improvements to ensure that the operator could reach the home, decreasing road improvement costs as well as road maintenance costs. Capital costs of necessary equipment are lower than for truck haul.

Disadvantages are that the tank cannot be as large as it is on a truck haul system, which increases the number of trips and amount of raw sewage handling, and decreases the level of service. ATV haul systems typically have in-home sewage storage and haul tanks between 120 and 300 gallons. Another disadvantage is that the homeowner must practice water rationing to limit the amount of hauls and keep the cost to the homeowner low. Water rationing does not promote good sanitation practices.

3.2.4.1.1 Truck Haul

A wastewater truck haul system is similar in many ways to one used for water haul. A truck- or trailer-mounted tank and pump are hauled to each residence and the wastewater holding tank is pumped out. The holding tank can be underground or inside the home. The tanks are fitted with quick disconnect cam lock fittings for easy cold weather hookup. The pumper then discharges the collected waste into a community septic tank or lagoon for treatment and disposal.

The O&M cost of this system is similar to the larger scale truck water haul, with fewer hauls per house per week. This means less cost to the homeowner (because the haul cost would likely be determined on a per trip basis) and less handling of the septic waste, which increases sanitation in the community. The waste would be stored and treated in controlled locations, increasing the sanitation benefit offered by the system. Truck haul systems are simple to operate and maintain, which is desirable in rural Alaska.

As with the other systems, disadvantages include the labor requirements to operate a haul system, a better maintained road system, and a larger maintenance building system than an ATV haul system, all of which increases capital and O&M costs.

3.2.4.1.2 On-site systems

Many of the potential town sites feature ice-rich soils. This permafrost is not suitable for onsite systems that depend on leaching for wastewater disposal, such as onsite septic tanks with leach fields. Depending on the soil temperature and type, and the amount of wastewater disposed, the frozen ground may eventually cause the liquids to freeze or the liquid may thaw the soil and create settlement problems.

3.2.4.1.3 Piped Collection

For this report, the village selected piped collection systems as the preferred alternative to be considered for all relocation sites. Many of the same parameters that were listed for piped water distribution also apply to piped sewage collection. This type of collection provides the highest level of service and the highest sanitation levels of all of the options. Several different options exist for piped sewer collection. Gravity, pressure, or vacuum sewer systems are all constructible in Kivalina depending upon the site chosen.

Gravity sewer collection systems are commonly installed in communities where suitable topographic relief is present. Wastewater flows by gravity from the house, downhill through a pipe, into the main collection lines and to a treatment/disposal location. With aboveground piping, the sewer pipes can be placed on piles to assist drainage; and for belowground pipes, this can be accomplished by installing the pipe at varying grades. Where sufficient slope cannot be reached to drain the wastewater to the desired location, lift stations are often installed. Lift stations pump the wastewater either to the treatment area or to a high point where gravity flow can resume. Lift stations require electricity to pump, as well as maintenance to ensure the pumps are clean and operating properly. The advantages of gravity sewers are that both capital and O&M costs are typically lower than those associated with other types of collection systems. The main disadvantage is that gravity sewer systems are completely grade-dependent and may only work in areas where it is topographically feasible.

Two options exist for pressure sewer systems. The first consists of the waste draining by gravity from the homes to a central sump (similar to a lift station) where it is pumped to the treatment location. The second option requires pumping the sewage from the home directly into the pressure sewer. This can be accomplished with the installation of either a grinder pump or a septic tank effluent pump (STEP) system. The grinder pump reduces the solids in the waste and produces a slurry, which is injected into the pressure main. The STEP system uses a tank to settle out the solids, and the remaining effluent is then pumped into the system. It is necessary to periodically pump the solids out of the septic tank to allow proper detention time for the effluent. Pressure systems are often used to pump effluent long distances where there are no service lines and not enough grade to flow by gravity, such as out to lagoons located away from the village. An advantage of pressure sewer systems is that because they are under pressure, achieving a downward slope is not necessary. Long distances can be covered without the need for deep excavations to maintain grade. This also makes construction easier because a specific grade does not need to be maintained during installation. The disadvantages are that pumps require electricity to operate, which increases operating costs, and pumps also require maintenance to perform properly, which requires time and labor. Pressure mains also require active heating and cannot be installed inside the same utilidor as a water main.

Another option that would be possible to construct in the village would be a vacuum system. Vacuum systems utilize vacuum valves, vacuum pumps, and atmospheric pressure to transport sewage from the homes to a central vacuum station. From there, the wastewater is pumped to a treatment and disposal facility. The advantages of a vacuum system are that it is less grade-dependent than a gravity system, and can transport wastewater uphill. If a leak occurs, it will not cause a spill, but rather cause the system to lose vacuum, which would alert operators of a problem. Leaks can be pinpointed more readily than other systems because of the many valves in the network. Vacuum mains can be located inside a single utilidor with adjacent circulating water mains that can provide heat without need for a separate glycol heat loop. A disadvantage of the vacuum system is that there are a large number of valves and moving parts involved, which increase the O&M cost and complexity. Homeowners must exercise care in using the system to prevent shutdowns and loss of service. A vacuum system in the village is possible to install, although the O&M costs are high and there are many technical requirements for maintaining the system. Vacuum mains should not be buried due to grade sensitivity.

3.2.4.2 Wastewater Treatment and Disposal

For a piped sewage collection system, there are three main types of treatment technologies that are typically used for small Alaskan villages: Septic tank /drainfields, package sewage treatment systems, and sewage lagoon systems. The design and construction of treatment and disposal facilities has to comply with Federal and State regulations. In summary, the regulatory authority set forth in 18 AAC 72 (Wastewater Disposal), the Alaska Department of Environmental Conservation (ADEC), regulates the design, review, and permitting requirements of the system. Specifically, the design and application submittals will conform to the requirements included in 18 AAC 72.010 and 18 AAC 72.205. A permit to operate the treatment system is also anticipated as described in 18 AAC 72.910.

For sites where soils conditions have sand, gravel, or a combination of sands/silts and gravel, a septic tank/drainfield system could be considered. However, based on preliminary geotechnical information, most of the village sites appear to have permafrost and saturated/silty soils that are not suitable for a septic tank/drainfield system. Without detailed geotechnical information, a septic/drainfield system cannot be further considered for this study.

Wastewater disposal alternatives are based on the type of wastewater treatment that is selected. Disposal is generally limited to discharge to water body, discharge to land, or discharge to subsurface. Surface discharge can outfall from a septic tank, package plant or sewage lagoon. The treated effluent flows into a pipe or surface containment swale to be dispersed over the surface of the ground or to a water course.

This method of effluent disposal needs to be contained by a fenced area to prevent accidental human contact. The site selection process for surface discharge requires the route and dispersal area to be a distance from the village, and the flow to be away from the village.

Marine outfall entails a pipe routed from land into the ocean to a depth allowed by regulations, and determined from tide and current studies. The discharge works by means of the pressure head between the treatment unit discharge point and the outfall discharge below the ocean surface. Marine outfalls are susceptible to wave/ice action and erosion, and can cause controversy regarding pollution of the marine environment.

3.2.4.2.1 Lagoons

Sewage lagoon systems are a common, low cost alternative used throughout Alaskan villages. Sewage lagoons naturally treat sewage without requiring pumps, equipment, power, heat, and testing/monitoring, For Kivalina, the most feasible low-cost method of wastewater treatment and disposal is a lagoon system. Sizing of the system is based both on biological treatment requirements and hydraulic requirements. EPA recommends the organic loading rate be limited to 20 lb/ac/day (22.4 kg/ha/day) Biological Oxygen Demand (BOD) to avoid over loading and anaerobic conditions and odors. During the cold winter months, natural biologically treatment is not effective, so lagoons are also sized to hold wastewater throughout the months when the lagoon is frozen. Lagoons are typically sized to hold sewage for a nine-month duration.

The main advantage of lagoons is that they are inexpensive to maintain once constructed. Based on a design population of 949 people, a single cell lagoon would have to be 8 acres in size with a 6 ft depth. Alternatively, a smaller footprint could be used if a 3-cell lagoon facility composed of a primary settlement cell (1 acre), a treatment cell (2 acres), and a polishing cell (2 acres). The polishing cell discharges treated sewage directly into a wetland or the ground. This size lagoon will meet the state standard for discharging to wetlands or a water body. The discharge is done either in the fall after the lagoon has experienced facultative action, or in the spring during break-up when little aquatic life is in the river system. The lagoon should be bermed and have a dimension ratio of approximately 2:1 in the flow direction. The lagoon and discharge swale should be fenced to prevent access by unauthorized personnel and ensure that flooding does not inundate the site..

Based on the 3-cell lagoon treatment recommendations listed above, the disposal of treated wastewater will either be to the surface or to a wetland.

3.2.4.2.2 Wastewater Treatment Package Plants

Package sewage treatment systems are also used for wastewater treatment in some Alaskan communities. In the regions surrounding Kivalina, package treatment systems are located in Emmonak, Chevak, and are used in the North Slope Borough villages. These systems are self-contained units that treat sewage prior to discharging to land application or to sewage lagoons. To prevent freezing, the treatment plants must be located in heated buildings. Sewage treatment plants require certified operators and ongoing wastewater quality testing/reporting. The ongoing operation and maintenance costs for a package treatment are much higher than sewage lagoon systems. Because of the high costs of operation and maintenance; requirements for highly trained and certified operators; and requirements for a warm building to house the treatment plant, this alternative has not been considered.

3.2.5 Solid Waste

3.2.5.1 Solid Waste Collection

The 1995 City of Kivalina Solid Waste Management Plan proposed the implementation of a Solid Waste Ordinance to adequately address ADEC solid waste requirements. The Solid Waste Ordinance states:

The City of Kivalina will administer solid waste management in the city according to the Solid Waste Management Plan. A utility manager will be directly responsible for the oversight and control of this operation.
Everyone within the city will be required to participate in managing his/her household's solid waste.
Individual yards will be kept free of unsightly waste. Littering is prohibited. Waste will be kept in proper containers.
The ordinance will regulate the disposal method, illegal dumping, and dictate fines for indiscriminate dumping.
The council will declare an annual village cleanup day, sometime after break-up. As an incentive, a prize for the most bags of trash will be offered to encourage resident involvement.

The current resident solid waste management and collection system is ineffective. The above Solid Waste Ordinance has not yet been implemented. Without enforcement of the Ordinance, residents do not properly dispose of solid waste. The current self-haul system does not meet 18 AAC 60 requirements and quality of life needs for the village. Implementation of the proposed Solid Waste Ordinance detailed in the 1995 City of Kivalina Solid Waste Management Plan would provide a starting point to begin development of an effective solid waste management and haul system. Other options for waste collection should be further evaluated during design of the new landfill.

3.2.5.2 Solid Waste Disposal

The new landfill should be sited and designed in accordance with 18 AAC 60 regulations as an unlined Class III municipal solid waste landfill. Although this landfill may not be designed specifically as a permafrost landfill, an aboveground design with insulating cover and side berms is recommended to minimize disturbance of underlying permafrost. Siting and constructing a new landfill requires:

- conducting an adequate soils investigation,
- locating the landfill in a stable, well-drained area and out of a flood plain,
- maintaining a minimum separation distance from groundwater and surface water according to ADEC standards,
- maintaining a minimum distance from the airport, and
- ensuring an accessible location of the landfill to Kivalina residents by road and to a docking area if hazardous materials are shipped out.

Hazardous material containment (such as storage and disposal of batteries, used oil, and other household hazardous waste), septic sludge, and recycling programs as well as the location of a sludge disposal pit must be considered during the design process. If stored properly, hazardous materials can be barged out of the village once a year to a safe disposal site.

A large burn box may help reduce the volume of burnable products in the landfill. Burn boxes have been successfully installed in several communities in recent years and have proved very effective at reducing the volume of trash that must otherwise be buried in a landfill. The State of Alaska allows and encourages burn boxes in rural communities, provided that the burn box acts only as designed for primary burning and not as an incinerator. State regulations must be met if an incinerator is installed. Material for daily or weekly covering of refuse should be stockpiled close to or inside the landfill. This material should be accounted for during design of cells, as well as the cost to have it stockpiled. Having cover material is essential to keeping debris from blowing out of the confined landfill and re-entering the community. It also prevents scavenging birds and animals from feeding on the waste.

Preliminary volume estimates have been calculated. Using 7.5 pounds per person per day, the uncompacted solid waste generated per year for a population of 949 is estimated at 10,391 cubic yards. To estimate the minimum uncompacted landfill volume capacity for twenty years, CRUM, 1996 was used. The average community growth rate was assumed to be 3.5% per year (TNH/URS, 2001). Assuming an initial population of 402 (current population) and a twenty five-year design life, the minimum landfill volume was estimated to be 259,788 cubic yards (October 2003 report). The given volume is an uncompacted volume. This volume may be reduced through compaction and burning to one-third to one-quarter of the uncompacted volume (CRUM 1996). Industrial and bulky waste would need to be estimated separately and added.

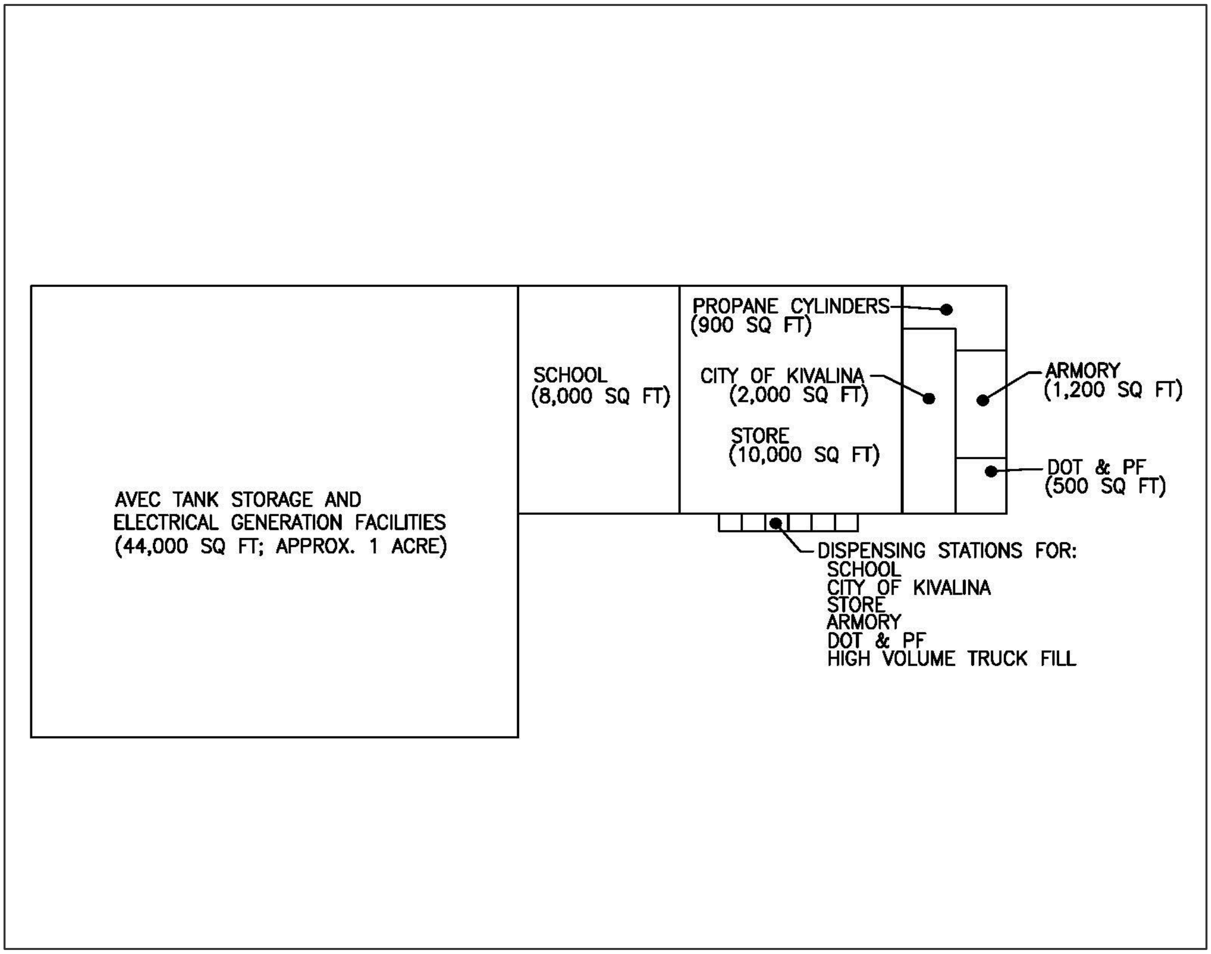
Calculation show the landfill will likely encompass 20 acres if no compaction or burning is performed. The landfill should be fenced to prevent the spread of blowing trash. In addition, the landfill should be sited a reasonable distance from the new village, above the flood plain, and out of any drainage paths. To minimize the number of roads required, it is recommended that the landfill be located along the access road from the village to the airstrip. The required separation distance between a landfill and an airstrip serviced by piston-type aircraft is 5,000 feet; however turbojet aircraft are used throughout the region and will likely access the Kivalina town site in the future; therefore a new landfill should meet the 10,000 foot separation distance required between a landfill and an airstrip serviced by turbojet aircraft.

3.2.6 Fuel

3.2.6.1 Fuel Supply

Separate marine headers should be provided at the barge docking point for the offloading of #1 fuel oil and gasoline for tank storage in the Bulk Fuel Storage (BFS) facility. Camlocks caps should be provided for barge marine header connections. Lockable block valves, check valves, and basket strainers with bolted covers and threaded bottom connections should be installed at the headers. A covered containment drip pan should be installed to contain minor spills and leaks.

Separate aboveground fill pipelines can be used to transport #1 fuel oil and gasoline from the marine header site to the BFS facility. Pipeline size and routing is site dependent; for pipelines longer than 2 miles, an additional booster pump station may be required to ensure adequate flow rates. Where the pipelines cross roadways, they should be installed underground with coated pipe and anodes for protection against corrosion. The fill pipelines should be connected to the tank headers for each type of fuel for filling of the individual bulk storage tanks. Trained personnel should protect against overfilling of the bulk storage tanks during filling operations by watching a tank's clock faced level gauge and by listening for an air operated whistle vent that alerts at 85% full. In addition to the gauge and whistle alarm, the tanks



Estimated Bulk Fuel Storage (BFS) Facility Area Allocations

should be individually equipped with automatic mechanical overfill valves.

3.2.6.2 Fuel Storage

The single, consolidated BFS facility should consist of multiple single-walled steel separate 27,000-gallon storage tanks for #1 fuel oil and gasoline. The BFS facility should be partitioned into individually secured areas to accommodate individual owners/users of the facility.

All bulk and dispensing tanks should be located within bermed and lined containment areas. The size of the contained area and the height of the berm should be designed to accommodate a spill equal to the largest tank, plus seasonal rainwater accumulation, plus 12 inches of depth. In addition, large bermed areas should be sectioned into smaller areas by fluid tight barriers in order to minimize spill area sizes.

Individual 100 lb propane tanks should be stored within a separate unbermed area adjacent to the fuel oil and gasoline BFS site.

The entire storage facility should be fenced with lockable gates and lighted for security purposes. Fences and lockable gates should also limit access to individual owner's areas within the BFS facility. Valves outside secured areas should be lockable.

Preliminary Bulk Fuel Storage (BFS) Facility Summary

Owner	Fuel Type	Projected Fuel Use (Gal) (1)	New Storage Req'd (Gal) (2)	New Fuel Tank Config (3)	New Tank Capacity (Gal)	Intermediate Tank Size (Gal)	Transfer Tank at BFS (Gal)
School	Fuel Oil	74,000	118,400	5 – 27,000	135,000	4000 (6)	5,000
City of Kivalina	Fuel Oil	8,000	8,000	1 – 10,000	10,000	4000 (6)	(8)
	Gasoline			1 – 5,000	5000 (1b)		(8)
Store	Gasoline	57,000	60,000	2 – 27,000		1,000 (7)	10,000
				1 – 10,000	64,000		
	Fuel Oil	98,000	104,400	4 – 27,000	108,000		10,000
	Propane	11,800 (4)	11,800 (4)		11,800 (4)		
AVEC	Fuel Oil	145,000	200,000	8 – 27,000			
				1 – 10,000	216,000	N/A	N/A
Armory	Fuel Oil	10,020 (5)	10,020 (5)	1 – 10,000	10,000		
	Gasoline			1 – 5,000	5,000		
DOT & PF	Fuel Oil	3000 (5)	3000 (5)	1 – 3,000	3000		

1. Tryck Nyman Hayes, Inc. bases fuel use projections upon modified numbers for a Kivalina population of 500 with plumbing as stated in the Oct 2003 ‘Relocation Planning Project’ report for Kivalina, Alaska. The numbers were modified as follows:
   a. School: The assumption of 1.13 gallons of heating fuel oil per sq. ft. per year was increased by 30% for the school building to account for increased ventilation rates required by today's building codes. The teacher's quarter’s fuel allotments were not increased.
   b. City of Kivalina: Listed in the October 2003 'Relocation Planning Project' report for Kivalina, Alaska by Tryck Nyman Hayes, Inc. as the "Washeteria," it is assumed the City of Kivalina will have either a community center or city office center as well as a washeteria. Therefore, gasoline storage and dispensing capability was added for City vehicles.
2. The October 2003 'Relocation Planning Project' report for Kivalina, Alaska by Tryck Nyman Hayes’s ratio of 'existing fuel oil used to existing fuel oil storage' was used to calculate the New Storage Required value.
3. Fuel tank configurations shown optimize the commonly used 27,000-gallon single wall storage tank.
4. Stored in individual 100 lb cylinders.
5. Based upon the existing capacity from the October 2003 'Relocation Planning Project' report for Kivalina, Alaska by Tryck Nyman Hayes, Inc.
6. Connected to and filled from the Bulk Fuel Storage facility via pipeline.
7. Filled manually via vehicle transport of fuel.
8. Combination 5,000-gallon fuel oil and 5,000-gallon gasoline (1 tank).
9. No transfer tank required; storage tank connected directly to dispensing station.

3.2.6.3 Fuel Distribution

All tanks of a common fuel type should be connected through isolation valves to the fuel fill and issue system header and pipelines.

Individually owned and operated duel fuel dispensing stations should be located near the BFS facility for local dispensing of either #1 fuel oil or gasoline. The dispensing stations should be equipped with arctic hose and dispenser nozzles with automatic shut off. Flow should be between 6 and 12 gallons per minute. These metering dispensers may be similar to those found at most gasoline stations on the highway system. Each individual dispensing station should be separately fenced, gated, locked for security, and covered with a roof for protection from the weather.

In the event that a fuel truck delivery system is provided for the village, a high volume pump or metering station should be provided for filling the delivery truck. All dispensed fuel should be pumped from transfer tanks associated with a particular Owner and dispensing station. The transfer tanks should be filled from the Owner's large storage tanks. In the case of Owners with storage tanks of 10,000 gallon capacity or smaller, a separate transfer tank may not be required.

A spill response building containing spill containment devices and cleanup kits can be stored near the BFS facility.

Individual self-priming fuel transfer pumps and distribution pipelines should be provided for the distribution of #1 fuel oil to the school and the City of Kivalina's intermediate storage tanks. The transfer pumps can be sized to transfer fuel at a rate of approximately 60 GPM. These pumps can be protected from running dry by a differential pressure switch and time delay relay control circuit. To control spillage, the pumps can be automatically controlled to run for 10 minutes (approximately 600 gallons) at which time a manual reset will be required for them to run for another 10 minute period. These 10-minute periods should continue until the desired quantity of fuel is transferred.

Individual double-wall intermediate building storage tanks may be provided for larger buildings or groups of buildings such as the school, washeteria, community center and/or City of Kivalina office building(s). Small buildings and private residences may have small individual storage tanks which may be filled manually via private vehicle transportation of fuel from a dispensing station located at the BFS facility.

The intermediate building storage tanks should be provided with three levels of overfill protection:

- Personnel will continuously monitor the level in the tank during filling operations. The tank will be provided with a level gauge, a whistle vent and an amber panel light to indicate when the tank is nearly full.
- Secondary overfill protection is provided via a float activated overfill protection valve with level switch and alarm that will stop the flow of fuel when the tank reaches a predetermined level above full (high alarm).
- A mechanical, float actuated fill shut-off valve provides the third level of overfill protection (high-high level protection).

Bulk fuel storage and distribution requirements for local emergency power generation equipment is not addressed at this time.

3.2.7 Heating

3.2.7.1 Public Facilities

Larger buildings and public facilities may be heated with a hydronic heating system utilizing #1 fuel oil-fired water boilers. Individual buildings should have an exterior double walled intermediate building storage tank and a small double wall interior day tank (approximately 50 to 100 gallons), where a small quantity of fuel is stored for a short period of time before being fed to the boiler. The small interior day tank should be equipped with a level sensor and should automatically transfer fuel from the exterior storage tank as required to keep itself full. Level sensors will detect an abnormally high level of fuel in the day tank and disable the transfer pump to avoid overfilling. The day tanks should also be equipped with overflow piping which directs fuel back to the exterior storage tank. A sensor in the secondary tank can detect primary tank rupture or leakage.

3.2.7.2 Private Residences

Private residences are heated with either a hydronic system utilizing #1 fuel oil fired water boilers or an oil fired hot air furnace system. Individual residences should be provided with small exterior storage tanks that are filled manually by hauling fuel from the BFS facility's dispensing station.

3.2.7.3 Heat Recovery System

Heat from the stationary engine-generator plant can be made available for use in public building hydronic and/or domestic water heating systems, or for use as added heat for freeze protection in the village's potable water distribution system. A heat recovery system could also be used to keep firefighting equipment in service throughout the winter months when tanks are subject to freezing.

In a heat recovery system, rejected heat is recovered from the generator's engine water jackets and/or from an economizer heat exchanger on the engine's exhaust manifold or pipe. This heat is then distributed via a heat exchanger and distribution system to wherever it can be used. Automatic temperature controls on both ends of the system determine when heat can be safely recovered and when it is available for use.

While there is an economic benefit to the recovery of heat, there are costs associated with the installation and maintenance of such a system. Seasonally, more heat becomes available during winter periods when demand for heat goes up. However, the inherently more complex nature of the temperature controls associated with a heat recovery system can render the system ineffective or useless if not maintained properly. An economic cost analysis is required to determine if a heat recovery system is feasible, and the commitment and ability of the system's maintenance personnel must be evaluated.

The heat recovery module should be located near the AVEC facility and within 1,000 feet of the customer connections to reduce heat transfer losses. A metered electrical service to the heat recovery module should be provided via a 240/120-volt single-phase 100 Amp service. The service should include a meter base and exterior disconnect and should be installed per AVEC service standard 93-23. Additionally, one metered 480-volt three-phase service for the electric boiler and one 480-volt three-phase feeder for the AVEC node pump and its controls should be provided. Connection to the services and feeder should be from an AVEC generator/control module and should be coordinated with AVEC.

A main heat recovery control panel provides control for building lighting, receptacles and the AVEC node heat recovery pump. The panel monitors system temperatures and drives the main circulation pump at variable speed proportionally to the electric boiler power. Secondary customer pumps are metered separately and driven via a winter/summer control scheme. Control panels will give visual status indication of pump operation; main pump speed and variable frequency drive fault status. Refer further to the mechanical section of this document for additional information regarding the heat recovery system and heat recovery feasibility.

Energy (BTU) meters are to be installed in the heat recovery module as well as the school. BTU meter data, boiler control data and the heat recovery module's electrical metering data should be used to accurately quantify the energy being consumed, recovered and transferred to customer site(s).

3.2.8 Electricity

3.2.8.1 Generation

Electrical generation facilities should be sized for a modest growth rate of the community, but should not be sized to immediately fill electrical demands for the 25 year growth projection of 949 people. Electrical generation facilities can be expanded as the community grows. For the new community, the facility should be sized for 500 persons living in new housing with plumbing. It is estimated that the electrical need will be 1.9 million kilowatt hours (M kWH) per year. This estimate includes the power usage for private buildings, community buildings, commercial buildings, school buildings, churches, the consolidated Bulk Fuel Storage (BFS) facility and the Alaska Village Electrical Cooperative (AVEC) station power, and allows for additional appliance usage and lighting required for the new village.

AVEC is the electrical supplier for the community and it is anticipated that it will also supply the community with electricity at the new site. A new power generation facility should include fully automatic control panels, individual cooling systems, support enclosures for hot and cold storage, lube oil storage, and living quarters. The facility should be of modular construction elevated on piles above grade in a configuration to reduce snowdrift problems.

An integral part of the AVEC generation facility should be the consolidated BFS facility. The BFS should be located adjacent to the AVEC power generation facility. A preliminary BFS facility layout can be found in the mechanical portion of this document. As discussed in that section, the BFS should feature separate containment areas for AVEC, City of Kivalina, the Northwest Arctic Borough School District (NABSD), the Kivalina store, the National Guard Amory and the ADOT&PF entities. Separate electrical distribution, lighting and fuel dispensers should be included for the separate BFS areas. Operations building(s) may also be provided near the fuel dispensers for conducting day-to-day fueling operations. Further discussion of the electrical systems in the BFS is included under the distribution section.

3.2.8.2 Wind Generation

AVEC has had some success using wind generation to supplement fossil fuel power generation. The potential difficulty of transporting fuel to some of the potential relocation sites makes wind generation an attractive and possibly essential option. It is not known which site location will be most suitable to make wind generation feasible, however the better sites are likely to be Tatchim Isua, Imnakuk Bluff or Kiniktuuraq. The installation of three or four wind generation turbines should be considered. Though most turbines may be connected directly to the power grid, AVEC has employed a means of utilizing turbine power off of the main power grid by connection to an electric boiler. Connection of the turbines to an electric boiler with integration to a heat recovery system allows usage of the off-peak surplus turbine power.

An electric boiler could be provided to produce hot water from the surplus wind generated electrical power. A control panel for the boiler should also be provided. The boiler control panel will allow accurate control of the electric boilers heat output. The boiler control panel can be monitored remotely to obtain energy consumption data.

3.2.8.3 Electrical Distribution

Primary electrical distribution should typically be overhead power lines, but underground lines may be used depending upon certain applications to the site selection. Those sites where substantial well-drained fill is required are best suited for underground utilities. Those sites with in-situ soils and potential permafrost problems are best suited for overhead utilities. Pad–mounted or pole-mounted transformers will convert 3-phase primary voltage to secondary 3-phase and single-phase low voltage (208/120 volts 3-phase or 240/120 volts single phase) for building electrical services. All services will meet AVEC service standards. The service sizes for typical private homes should be 100 or 200 Amp, 240/120 volts single phase and 200 Amp or greater 208/120 volts 3-phase for community buildings, commercial buildings, school buildings and churches. All electrical services should be metered, with demand type metering employed for commercial and larger community buildings.

Pole-mounted light fixtures should be provided for street lighting. High pressure sodium (HPS) fixtures with cutoff optics at 100 or 250-watt sizes will likely be used as these are usually readily should be metered for billing to the appropriate entity.

Electrical service to the BFS site should be provided to the site from the AVEC operations building. A transformer can serve multiple separate 240/120-volt single-phase 100 Amp services. The services include a meter base and exterior disconnect, and should be installed per AVEC service standard 93-23. Electrical power to all devices in the BFS site should be provided by load centers via fuel control panels. Devices in the BFS bulk fuel area include lighting, pumps and controls. A fuel control panel for each entity should be provided. Fuel control panels and load centers will likely be installed inside of an operations building near the fuel dispensers. Branch circuits should be provided for building lighting receptacles and fuel control panels, devices and ventilation. Rough service fluorescent light fixtures with cold weather ballasts should provide for interior lighting.

3.2.8.4 Communications

Because of limitations in delivery methods, primary communications services will be delivered to Kivalina via satellite, as is the case in most isolated Alaska communities. Communications should be distributed in the new village via copper cabling, fiber optic, and cable television.

The copper communications cabling system should be routed from the Kotzebue Telephone Cooperative (OTZ) and ALASCOM to all locations in the community. A minimum total of 2500 pair copper is required for serving the community.

A single mode optical fiber communications cabling system should also be installed. Fiber should be routed from the OTZ and ALASCOM to schools, commercial buildings, and larger community buildings in the community. The higher performance and speed of a fiber connection to these buildings is especially critical for applications such as distance learning programming. A minimum total of 200-strand single mode fiber is required for serving the community.

A cable television distribution system should be provided. Coaxial cabling with necessary distribution components should be routed from the OTZ and ALASCOM to all locations in the community. Optical fiber cabling may also be used instead of, or in additional to, coaxial cabling for transmission of video signals.

As with the electrical distribution, communications distribution can be either overhead or underground (direct bury), depending upon the site selection.

3.2.9 Access

For each alternative, access to the sites must be provided for barge landing and boat landing facilities, which can be connected to the community via a road. The airport, landfill, and other boat access points to the lagoon and rivers can also be on the road system. Without additional geotechnical information, it was assumed that the soil conditions around all sites are similar and the general structural cross section will remain relatively the same, though the length of the road may vary.

With the exception of the existing site of Kivalina, each site should have a gravel staging pad at the lagoon to serve as a haul-out and dry storage area for boats. Ideally, the boat staging area should be on the route from the barge landing to the village.

3.2.9.1 Subsistence Access

As discussed in Section 2.2.1, subsistence activities contribute significantly to the culture and economy of Kivalina. Maintaining traditional access to subsistence areas must be considered in the selection and layout of a new village site. Access to subsistence areas is gained by boats, four-wheeler, snow machine, and on foot.

Water access is critical for the new village. The community is a coastal culture depending on close proximity to the ocean for a large part of their subsistence needs. Water access from the lagoon should allow egress to the rivers to the east and ocean to the west. All sites will need an access route from the village proper to the lagoon for boat moorage and subsequent use of the marine and riverine subsistence environments.

The villagers will require access to the Chukchi Sea, the lagoon, and nearby rivers. The existing village site provides excellent access to the lagoon from the east side of the village, which in turn provides access to the Kivalina and Wulik river channels as well as to the Chukchi Sea. The rivers provide access to inland subsistence areas.

The particular configuration of accesses shall depend on the location of the new village. Individual problems associated with topography, distance and ground type will affect what design criteria and methodologies are employed. Continued access to river entrances from the lagoon should be considered when selecting a new village site. A road from the new village site to the lagoon may be necessary for continued access needs. However, if a road is not developed, the new site could provide continued access to subsistence areas via river access to the lagoon.

3.2.9.2 Bulk Goods and Fuel Access

The community has three main methods of obtaining bulk goods, fuel, and supplies: barge access to the ocean, barge access to the lagoon, and by air. There are two barge deliveries to Kivalina every year, both in the summer.

A barge landing is very simple, consisting only of two concrete deadmen large enough to securely hold the moored barge. To maximize efficient loading and unloading of the barge, a land route into the village to distribute goods must be constructed and maintained, as well as a staging area. The staging area should be at the immediate site of the barge landing to allow temporary storage of loaded and unloaded goods. This should allow the barge to maintain a short turn-around time, and the community to ferry goods into the village at their own pace.

The estimated area for the staging area is one acre. This should allow goods stacked on the barge to be placed on the ground for easy loading and transport to the community.

While landing on the ocean beaches can be acceptable for barge traffic, at times heavy seas make loading and unloading a beached barge very difficult. If an ocean barge landing is selected as a best option, then a breakwater should be constructed to provide protected moorage to ensure the barge's ability to land at the site.

3.2.9.3 Air Transportation

The existing airstrip provides almost daily aircraft access to the village by small planes and some larger propeller-driven, cargo aircraft. All of the village's mail is brought by air. Since barge trips are infrequent, most cargo, such as groceries and personal goods, is brought to the village via air.

Siting of the new airport must take into consideration soil conditions and required depth of gravel, distance from the new village, distance from the landfill, wind conditions, and flight path safety.

Air transportation for the new village, including access to emergency air evacuation, should be through the existing airstrip until a new airport is located, designed and constructed. The master relocation schedule includes construction of the airport prior to the construction of any structures. The new airstrip should be in operation as people move into the village.

The new airstrip should be located within a convenient distance to be driven by four-wheeler/snowmobile during the winter. An airstrip that is located further from a village could result in increased travel and costs associated with getting passengers and freight to and from the airport. In addition, the long distance raises concerns regarding emergent evacuation and access during bad weather. The runway length of 4,000 lf for each site has been taken from the 1998 USACE report. This length should allow a C-130 Hercules aircraft at 130,000 lbs. to take off and land.

The locations of airstrip runways for this report have been obtained from existing literature as much as possible. For several sites, the location of a runway proposed in previous reports can serve more than one of the sites. Access road lengths and routes have been adjusted from the sites to accommodate a single runway location.

3.2.9.4 Road and Streets within the Community

The relocated village layout selected during the Phase I study features a grid type road system (Appendix G). Oriented properly, this type of system is easy to navigate, maintain and provides protection from snow drifting. Since road funding could be obtained through BIA, road design and construction should follow BIA standards of a 20-foot wide road. Other road standards should apply; however, the typical road section is likely to consist of two 8 ft wide lanes flanked by 2 ft shoulders. The road depth will be the thickness of the gravel pad or 5 feet thick, whichever is greater, and side slopes should have a grade of 2:1. This should allow four-wheelers to pass each other side-by-side and share the road with pick-up trucks. The relatively small size of the road should help keep costs down.

All roads associated with the new community, both inside and around the village, should be gravel. No paved roads are planned at this time. Design of the roads should be based on geotechnical recommendations, but a minimum structural roadbed depth of 5 ft is anticipated with the top 6 inches being a crushed surface course to facilitate ease of maintenance.

The actual design of the roadway structural gravel section will depend on the site selected. For sites where the subgrade is composed of silts and clays, a geotextile separation fabric can be used to provide separation and added support to the road prism. The roads should be crowned at 2-3% to drain to each shoulder. Run-off should be carried in roadside ditches to low points where HDPE culverts should be installed to transport the water to main drainage channels, and then off the site.

One problem noted in the existing village that will need to be addressed in the design and maintenance of the roads for the new community is the displacement of gravel caused by high-speed 4-wheeler traffic. A method of controlling four-wheeler speed in the village will need to be developed to ensure the required maintenance to keep the new roads/streets in good shape.

The community has requested fire hydrants to facilitate fire fighting. The hydrants can be located in the street rights of way, and should have a 'clear zone' staked around them to preclude placement of private structures that can endanger access during a fire.